Comparison of Water Consumption for the Conversion of Croplands to Orchards in Dryland Ecosystems

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ABSTRACT

Evapotranspiration (ET) is the main ecological and soil water consumption process in terrestrial ecosystems. Previous studies have investigated ET partitioning across sites and plants; however, direct comparisons of water consumption before and after the transition from one crop to another are scarce. The variation in and proportion of ET and its subcomponents as well as the change in soil water storage (SWS) were compared in maize (*Zea mays* L.) croplands and apple (*Malus domestica* cv. Fuji) orchards in four active (approximately May to September) and three inactive growth periods on the southern Loess Plateau, China. Soil water evaporation (E_s) accounted for 36.3% and 37.7% of the total ET for cropland and orchard, respectively, in the active growth period. The canopy interception (I_c) significantly differed between cropland and orchard. The mean I_c/ET for cropland and orchard was 23.1% and 22.7%, respectively, in the active growth period, showing that the effects of I_c on ET partitioning should not be ignored. The mean ratio of transpiration (T) to ET for cropland was 2.8% less than that for orchard during the active growth period. The T/ET of cropland peaked twice in each active growth period. Precipitation (P) met the water consumption requirements of crop growth in the active growth period. The ET of cropland and orchard in the inactive growth period accounted for 29.4% and 31.8% of the ET for the hydrological year, respectively. These results help assess water consumption and soil sustainability under changes in crops in dryland agricultural ecosystems.

ABBREVIATIONS: ET, evapotranspiration; E_s, soil water evaporation; I_c, canopy interception; T, transpiration; SWS, soil water storage; LAI, leaf area index; P, precipitation

KEYWORDS: Water consumption, Evapotranspiration, Transpiration, Soil water evaporation, Canopy interception

1. INTRODUCTION

Any precipitation (P) that passes through the vegetated landscape is bound to interact with plant surfaces (Van Stan et al., 2020). Before falling to the ground, a portion of P is first intercepted by the canopy and returned to the atmosphere by evaporation (called canopy interception, I_c) (Wang & Wang, 2018a). The P across the canopy replenishes the soil reservoir and is also absorbed by plants (Zhao & Zhao, 2014). The interaction between the environment and plants maintains regional water balance and global climate stability (Wu et al., 2021). Climate change will affect the variation in hydrological patterns in different regions, and the availability of soil water for plants will become less predictable in terms of amount and seasonality (Scott et al., 2021). Specifically, these effects could have a great influence on rainfed agricultural areas, which account for 80% of the global arable land (Ma et al., 2020). Therefore, the amount of water consumed in water-limited rainfed areas should be studied.

Water consumption in dryland agricultural systems mainly occurs through evapotranspiration (ET), especially in areas with flat terrain (Qiao et al., 2015). When there is no understory or litter layer, ET typically comprises both soil water evaporation (E_s) and transpiration (T), as well as I_c. Canopy interception has been ignored in many previous crop studies (Gong et al., 2007; Kang et al., 2003; Wang et al., 2020). However, studies have found that I_c is also an important component, accounting for 20.0 ± 8.7% of the total ET at the global scale (Good et al., 2015). Thus, ET can be partitioned into evaporation (E_s and I_c) and T subcomponents (Sun et al., 2019; Wang et al., 2020). The water loss by ET from vast rainfed agricultural landscapes strongly influences regional climates, while the remaining water that is not lost through ET determines surface–groundwater interactions (Hussain et al., 2019). Understanding ETsubcomponents and soil water balance processes are therefore essential for determining the ecological water balance and cropping system sustainability in water-limited environments (Wang et al., 2021).

Assessing the water consumption of each component in a dryland ecosystem can be facilitated by ET partitioning (Ma et al., 2020). Previous research has explored factors that affect plant water consumption, i.e., E_s, I_c and T. Studies have shown that the ET of plants is affected not only by environmental factors such as solar radiation (Wang et al., 2021), P (Wang & Wang, 2018a; Wu et al., 2021), air temperature (AT) (Hussain et al., 2019), and soil water availability (Scott et al., 2021) but also by physiological factors such as the leaf area index (LAI) (Hussain et al., 2019; Ma et al., 2020; Sun et al., 2019) and root systems (Wu et al., 2021). However, some studies on *ET* and each subcomponent and their influencing factors were conducted only during the plant growing season (Ma et al., 2020; Srivastava, Panda, Chakraborty, & Halder, 2019) or concentrated-*P* period (Wang & Wang, 2017). Thus, the study of plant water consumption at the hydrological year scale is important to ensure the sustainability of the soil environment and to ensure an ecological water balance (Yimam et al., 2014). The effects of different plants on water use patterns and soil water conditions may be different even under the same growth conditions (Wang et al., 2021). Crops change over time, which potentially affects water loss in agroecosystems and hence water balances in specific ways (Hussain et al., 2019). For example, Jia et al. (2017) found widespread decreases in regional losses of soil water due to the conversion of agricultural land to forestland on the Loess Plateau of China. However, direct comparisons of water consumption differences between crop types before and after a change in crops are scarce.

The Loess Plateau of China is a typical agricultural area, and one of the main traditional crops planted on the plateau is maize (*Zea mays* L.) (Gong et al., 2007). Currently, the amount of harvested maize meets the farmers' demand for food, and surplus maize is converted into economic income. However, the contradiction between farmers' increasing standard of living and economic income will give rise to more unsustainable farming, which will greatly harm the natural soil and water environment and reduce the sustainability of farming livelihoods. Under the national “Grain to Green” policy, apple (*Malus domestica*) orchards have been gradually planted to replace traditional crops. As an example, the total planted area of apple orchards increased from 260.0 km^2 in 2000 to 6201.8 km^2 in 2020 in Shaanxi Province, while the cropland area decreased from 38215.9 km^2 in 2000 to 30010.5 km^2 in 2020. Apple orchards provide ecological benefits in terms of water and soil conservation as well as rich economic benefits (Wang & Wang, 2018b). As of 2020, the apple industry increased by 59 billion yuan, accounting for 34.6% of the increase in the total agricultural value of the province. Rural vitalization will be promoted by the development of the apple industry over the long run. Therefore, this study aimed to (1) quantify the difference in ET and its subcomponents between traditional crops and economically important orchards across multiple time scales, (2) compare the changes in soil water storage (SWS) in different profiles, and (3) identify the characteristics of water consumption at the hydrological-year scale for the conversion of croplands to orchards.

2. MATERIALS AND METHODS

2.1 Study Sites

The field study was carried out at the Changwu Agro-Ecological Experiment Station (107°40′–107°42′E, 35°12′–35°16′N, 1100–1300 m above sea level [a.s.l.]) in the southern region of the Loess Plateau of China (Figure 1). The main geomorphic landform of this region is tableland. This region has a continental monsoon climate with cold winters and hot summers and is dominated by dryland farming. The mean annual temperature is 9.1 °C. The mean annual P was 535.7 mm in 2000–2020, most (55.0–78.0%) of which occurred from

June to September. The soil is a light silty loam with uniform texture (Mu et al., 2020). Precipitation is the most important available water resource for agroecological systems in this region because the groundwater level is 50–80 m beneath the surface.

The main land use type in the present study was cropland, including maize croplands and apple orchards. Spring maize (*Zea mays* L.) grew from mid-April until harvest in mid-September, and the area of croplands in the Changwu tableland was approximately 24.0 km^2 in 2019. Apple (*Malus domestica* cv. Fuji) trees bloom in late March, and the fruit are harvested in early October. The area of apple orchards in the tableland was 167.7 km^2 in 2019. The selected apple trees were 12 years old, at which point the trees were in the prime stage of their growth cycle. We defined the hydrological year from May of the previous year to April of the subsequent year and the period from May to September as the active growth period, with approximately October to April constituting the inactive growth period.

2.2 Meteorological Variables

Meteorological data were collected during 2017–2020 and are shown from May to September in Figure 2. Precipitation was measured using a tipping-bucket gauge (RG13) at a meteorological station located in a cleared grassy area approximately 300.0 m away from the experimental fields. The air temperature (°C, AT) and relative humidity (%, RH) at a height of 2 m, wind speed (m s^{-1}, Ws) at a height of 10 m were also monitored by the meteorological station (M520, Vaisala Company, Finland). Potential evapotranspiration

(PET) was calculated from daily weather data, which included mean AT, maximum AT, minimum AT, sunshine duration (N), mean RH, mean Ws (Allen et al., 1998). To understand the synergistic effect of AT and RH, the vapor pressure deficit (VPD, kPa) was calculated as follows (Campbell and Norman 1979):

$$es = 0.611 \times Exp\,(\frac{17.502 \times AT}{AT + 240.97})$$

$$VPD = es - \frac{es \times RH}{100}$$

where es is the saturation vapor pressure (kPa).

The soil temperature (ST, °C) was considered the mean temperature at depths of 0, 5, 10 and 15 cm and was measured with a probe (107 L) connected to a CR1000 data logger (Campbell Scientific, Logan, UT, USA). The sample point of ST was located at the center of the field, with two replicates for each soil layer.

2.3 Leaf Area Index (LAI)

The LAI was measured weekly from May to September in 2017–2020. The studied cropland is located in the area southwest of the studied orchard, approximately 200.0 m away. There were six replicates of the maize plot (16.5 m long, 10.0 m wide) and eight replicates of the orchard plot (14.0 m long, 10.0 m wide). The sample points were generally located at the center of each field or at 1/4 of the diagonal. A standard digital single-lens reflex (SLR) camera equipped with an optical fisheye lens (Nikon D7200 + Nikon AF DX 10.5 mm f/2.8

G ED) was used to take 8–10 images of each field. Image preprocessing and LAI extraction from the images were conducted using CAN-EYE v6.47 software.

2.4 Root Parameters

Five maize plants were selected from which to collect root samples according to an “S”-shaped pattern in July 2020. After the maize plants were cut down, the center root sample was collected by using a root auger (with an internal diameter of 8.5 cm). Then, root samples from four different sides in relation to the main stem (0, 90, 180 and 270°) were obtained at the same distance (5 cm radial distance from the main stem). Three apple trees were selected from which to collect root samples. Root samples from three different sides in relation to the main tree trunk (0, 120, and 240°) were collected at different distances (40, 120, and 200 cm radial distances from the main tree trunk). The obtained roots were spread out on paper, sprayed with water, and then stored in a refrigerator. The soil with roots was sieved and washed carefully in a 1 mm sieve before the roots left on the sieve were removed with tweezers. Cleaned roots were spread out on a plexiglass dish filled with a small amount of water. The roots were scanned by an Epson V370 scanner, and the root length and root surface area were determined using WinRHIZO Reg. 2012b software.

2.5 Total Evaporation

2.5.1 Canopy Interception (I_c)

Precipitation was partitioned into three fractions during and after rain: the water dripped from the plant canopy and through gaps (called throughfall, TF), flow down the stem (called stemflow, SF) and I_c. There were six and eight replicates of the maize and orchard plots in TF and SF were measured, respectively. Two maize and one apple tree located in the center of each plot were selected for the measurement of SF. The SF was collected with breathable but dense sponges that were wrapped around the stems in a cone shape. A container was connected by a pipe, and the weight of rainwater was determined by an electric balance with a precision of 0.1 g. An iron trough (90.0 cm long and 50.0 cm wide) was positioned between rows at the center of each maize plot to capture the TF. Eight rain gauges (inner diameter of 20.0 cm and height of 30.0 cm) were installed underneath the selected tree at a distance of 50.0 cm and evenly around the tree. Canopy interception (I_c, mm) was calculated as follows:

$$I_c = P - TF - SF$$

where P is the precipitation (mm), TF is the throughfall (mm), and SF is the stemflow (mm).

2.5.2 Soil Water Evaporation

Soil water evaporation was measured using microlysimeters, which consisted of PVC cylinders (cross-sectional area, 86.5 cm^2; height, 10.5 cm). Two microlysimeters were installed near each selected tree, one below the canopy and the other in the gap between trees. One microlysimeter was installed in the center of each maize plot. In total, sixteen and six microlysimeters were installed in the apple orchard and cropland, respectively. The microlysimeters were weighed daily at 8 a.m. using an electric balance with a precision of 0.1 g. The soil in the microlysimeters was replaced every 5–7 days and after a heavy rain event (greater than 5 mm d^{-1}). Soil water evaporation (E_s, mm day^{-1}) was calculated as follows:

$$E_s = \frac{\Delta W/\rho}{S_m} * 10$$

where ΔW is the microlysimeter weight difference between 1 day and the following day (g), S_m is the microlysimeter area, and ρ is the density of water (g cm^{-3}).

The total evaporation E (mm) was calculated as follows:

$$E = E_s + I_c$$

where E_s is the evaporation from bare soil (mm) and I_c is the evaporation from canopy interception (mm).

2.6 Partitioning of the Water Balance Components

On the Loess Plateau, the storage of P is mostly limited to the 0 to 200 cm soil layer (Jin et al., 2011; Zhang & Shangguan, 2016). In this study, the 0–300 cm layer was selected to evaluate the changes in SWS (ΔSWS). The SWS was measured by a neutron probe (CNC503B) on approximately the 15th and 30th day of each month from April 2017 to December 2020. Three tubes were evenly installed on the centerline of cropland and orchard along the long side of the plot. Soil water storage (SWS) was calculated as follows:

$$SWS = SWC_i * h_i$$

where SWC_i is the soil water content (cm^3 cm^{-3}) in a soil layer of depth h_i (10 cm for the 0 to 100 cm layer and 20 cm for the 100 to 300 cm layers).

The general water balance equation of Mu et al. (2020) was calculated as follows:

$$P + I + E_g = R_i + R_s + ET + I_p + \Delta SWS$$

where P is the precipitation amount, I is the irrigation amount, E_g is the replenishment of groundwater to soil water caused by capillary lift, R_i is the subsurface runoff, R_s is the surface runoff, ET is the evapotranspiration (including total evaporation and [T]), I_p is the deep seepage, and ΔSWS is the change in soil water storage. The soils are relatively deep (>50 m) and flat. The soils have a strong infiltration capacity, for which the steady infiltration rate is 1.35 mm min^{-1}. Therefore, the effects of E_g, R_i, R_s, and I_p can be ignored. The simplified water balance equation for ET estimation was calculated as follows:

$$P = ET + \Delta SWS$$

T was calculated as follows:

$$T = P - E - \Delta SWS$$

2.7 Statistical Analysis

The t tests and ANOVA were performed to determine whether there was a significant difference in E_s, T and I_c between cropland and orchard. The correlations of E and T between meteorological variables (ST, AT, P, RH, Ws, VPD) were analyzed using Pearson correlation analysis. Potential evapotranspiration was calculated according to FAO standards via calculator (version 3.2) developed by the Land and Water Division of FAO. Repeated-measures ANOVA was used to analyze differences between the LAI over time. Statistical analyses were performed via SPSS software v24.0 (SPSS, Inc., USA), with the significance level set at 0.05. All the figures were constructed using Origin 2018 (OriginLab Corporation, USA) for Windows.

3. RESULTS

3.1 Meteorological Conditions

Figure 2(a) shows the daily and monthly values of P from May 2017 to September 2020. The cumulative P values of the three hydrological years were 556.6 mm, 576.8 mm and 717.6 mm, and the total P values of the four active growth periods were 377.6 mm, 468.9 mm, 570.4 mm and 437.1 mm. The majority of P events were ≤5 mm, accounting for 90.4% of the total P events. The AT showed obvious regularity with the change in season within a given year (Figure 2(b)), and the daily mean value of AT was 18.5 °C. Figure 2(c) shows the daily mean values of Ws and RH. The daily mean value of Ws was 1.1 m s^{-1}, and it rarely exceeded 1.8 m s^{-1}. The daily mean ST of cropland and orchard was 21.2 °C and 19.5 °C in the active growth period, respectively (Figure 2(d)). The maximum monthly mean ST of cropland and orchard occurred in the same month (July, August, July, June), as did the minimum monthly mean ST (September, September, May, September).

3.2 Amount and Proportion of E and T

Table 1 shows the amounts of E (E_s and I_c) and T close to the 2-week scale in the active growth period of the maize cropland and apple orchard from 2017 to 2020. The range of the standard deviation of the individual microlysimeters of cropland and orchard was from 0 to 2.4 and from 0 to 2.0, respectively. The proportions of standard deviation for cropland and orchard within 1.0 were 94.6% and 96.0%, respectively. The same increasing or decreasing trend in the E_s was monitored from this 2-week interval to the next 2-week interval in each active growth period. The peak E_s of cropland was 23.8 mm, 37.7 mm, and 36.8 mm and that of orchard was 26.0 mm, 30.2 mm, and 32.2 mm, which occurred during the same interval in 2017, 2018 and 2020, respectively. The E_s peak periods of cropland and orchard were inconsistent only in 2019. Before 31 May 2017, 6 June 2018, 18 June 2019 and 30 June 2020, the differences between cropland and orchard were 3.9 mm, 10.8 mm, 10.8 mm and 7.8 mm, respectively, and more soil water evaporated from cropland than from orchard. Then, until the maize was harvested, the E_s during each 2-week interval in cropland was less than that of orchard. Except in 2018, the total E_s of orchard in the active growth period was greater than that of cropland, with a mean of 16.0 mm. There was a significant difference in total E_s between cropland and orchard according to ANOVA (p<0.01).

The mean total I_c of cropland and orchard was 113.9 mm and 74.6 mm in the active growth period, respectively. The total I_c values of cropland were 18.6, 24.8, 63.9 and 50.2 mm higher than those of orchard in each active growth period. The time when the I_c of orchard was greater than that of cropland occurred mainly in May, June and September. The peak time of cropland I_c occurred in August 2017, 2018 and 2020 and in September 2019, while that of orchard occurred from late June to early July 2017 and 2018 and from late July to early August 2019 and 2020. There was a significant difference in I_c between cropland and orchard according to t tests and ANOVA (p<0.01). The mean I_c/ET for cropland in the active growth period was 23.1%, and that for orchard was 22.7%.

The seasonal pattern in T in both cropland and orchard were consistent, and there was a difference only in 2018. The variation in T for cropland and orchard was highest from 3 August–17 August in 2017, 7 July–15 July in 2018, 22 July–5 August in 2019, and 6 August–19 August in 2020. The mean T of cropland was 13.6 mm, 19.0 mm, 21.3 mm and 17.4 mm in each active growth period, and that of orchard was 15.6 mm, 16.4 mm, 25.5 mm and 18.5 mm, respectively. Except in 2018, the total T of the apple orchard in the active growth periods was greater than that of the maize cropland; the values were 19.6 mm, 38.0 mm and

7.9 mm for 2017, 2019, and 2020, respectively. There was a significant difference in T between cropland and orchard according to t tests ($p<0.01$).

The total E of cropland in each active growth period from 2017–2020 accounted for 60.2%, 57.8%, 56.3% and 63.4%, respectively, of the ET (Figure 3). Similarly, the total E of orchard in each active growth period for the same four years accounted for 57.9%, 56.8%, 51.8% and 59.9%, respectively, of the ET. The mean T/ET of cropland was 2.8% less than that of orchard during the active growth periods. The T/ET of cropland exhibited two peaks in each active period; the peaks mostly occurred from late May to late June and from early July to late August.

3.3 Comparison of SWS Changes

The changes in SWS at 100 cm intervals in the active growth stage during 2017–2020 is shown in Figure 4. The SWS in the 0–100 cm layer of cropland and orchard changed greatly with time, and the SWS in the 0–100 cm soil layer was generally greater than in the layers below 100 cm. The SWS variation range of the 0–100 cm soil layer of cropland was 163.2–265.7 mm, 208.4–269.4 mm, 211.5–265.0 mm and 198.0–254.5 mm in 2017–2020, respectively. The SWS variation range of the 0–100 cm soil layer of orchard was 144.0–261.7 mm, 188.5–285.1 mm, 207.6–261.6 mm and 190.0–264.6 mm in 2017–2020, respectively. The SWS of the 0–100 cm layer of cropland soil was greater than that of orchard soil during part of the active growth period. The trends of SWS for cropland and orchard at the same timescale were different, but the trend of each active growth stage was essentially consistent. The ΔSWS of the 0–300 cm soil layer in cropland ranged from -36.1 mm to 79.1 mm and that in orchard ranged from -42.0 mm to 117.0 mm in the active growth period during 2017–2020.

3.4 Characteristics of Water Consumption During the Active Growth Period

The ET of cropland was 366.4 mm, 417.5 mm, 494.9 mm and 342.6 mm, and the ET of orchard was 378.4 mm, 354.7 mm, 486.9 mm and 313.3 mm in each active growth period during 2017–2020, respectively. The ET from cropland was less than that from orchard during the active growth period of 2017, while the ET was greater in cropland than in orchard in 2018–2020. There was no significant difference in ET between cropland and orchard. The mean values of ΔSWS and ET in the active cropland growth period were 54.3 mm and 405.4 mm, respectively, and the mean values for orchard were 76.2 mm and 383.3 mm, respectively. During the active growth period of 2017, the total ΔSWS in the 0–300 cm layer in cropland was higher than that in orchard ($p>0.05$), while the total ΔSWS in 2018–2020 was less than that in orchard (Figure 5). Changes in SWS increased during the four active growth periods in both cropland and orchard.

3.5 Characteristics of Water Consumption During the Inactive Growth Period

The ΔSWS values of cropland in each inactive growth period were 33.1, -71.1 and -86.2 mm, while those in orchard were 50.5, -117.3 and -105.6 mm (Figure 6). The variation in SWS in cropland in each inactive period was less than that in orchard. The ET values in cropland in each inactive growth period were 107.7, 179.0 and 272.0 mm, while those in orchard were 90.3, 225.2 and 291.4 mm. There was no significant difference in ET or ΔSWS between cropland and orchard during the inactive period. According to one-way ANOVA, the difference in ΔSWS between the 0–100 cm, 100–200 and 200–300 cm soil layers in cropland was not significant in any of the three inactive growth periods. However, there was a significant difference in ΔSWS between the 0–100 cm and 100–200 cm soil layers in orchard, albeit only in the inactive growth period of 2017–2018 (p=0.014). The mean values of ΔSWS and ET in cropland in the inactive growth period were -41.4 mm and 186.2 mm, respectively, and the mean values of ΔSWS and ET in orchard were -57.5 mm and 202.3 mm, respectively.

3.6 Characteristics of Water Consumption During Each Hydrological Year

The mean annual ET of cropland in the inactive growth period accounted for 29.4%, of the ET of the hydrological year (Table 2). The mean ET and ΔSWS for the hydrological year in cropland were 612.5 mm and 18.1 mm, respectively. The mean annual ET of orchard during inactive growth periods accounted for 31.8% of ET in the hydrological year. The mean ET and ΔSWS for the hydrological year in orchard were 609.0 mm and 21.5 mm, respectively. The ET of orchard was greater than that of cropland only in the hydrological year 2019–2020. The proportion of ET in each inactive period of the total ET for orchard was greater than that for cropland in 2018–2019 and 2019–2020. The total ΔSWS at the hydrologic scale of orchard was less than that of cropland only in 2018–2019. The surplus ΔSWS in cropland was 54.4 mm, and the surplus ΔSWS in orchard for the three hydrological years was 64.5 mm.

3.7 Correlations of ET with Meteorological Variables and with Plant Traits

3.7.1 ET in Relation to Meteorological Variables

Pearson correlation analyses revealed that the E of cropland was significantly correlated with P ($p<0.01$) each year, while the E of orchard was significantly correlated with P only in 2017 and 2019 (Table 3). The E of orchard was significantly correlated with AT and RH only in 2020. Moreover, Ws and ST were not correlated with E in either cropland or orchard. Soil water evaporation and P showed correlations in 2017 and 2019 in cropland, while T and P were correlated in 2017, 2019 and 2020 in orchard. T showed a correlation with AT in 2018 in both cropland and orchard. The VPD was only correlated with the T in orchard in 2017. The ET values of cropland and orchard were significantly correlated with P in 2018–2019 and 2019–2020 ($p<0.01$), with average correlation coefficients of 0.856 and 0.697, respectively (Table 4). The mean PET was 338.1 mm during inactive growth period. Annual PET was 913.2, 917.6 and 941.4 mm in 2017-2018, 2018-2019 and 2019-2020, respectively. The relationships and comparisons between PET and ET for the maize cropland and orchard during the experimental periods are shown in Figure 7. The PET and ET were positively correlated both in maize cropland and orchard during active growth period. The maximum difference of PET and ET for maize cropland and orchard occurred in 2019-2020 during inactive growth period and hydrological year.

3.7.2 Plant Traits

Figure 8 clearly shows that the LAI generally increased with growth for both maize plants and apple trees. The LAI trends for cropland and orchard were consistent, first increasing to a maximum and then decreasing gradually. However, the time at which the LAI of cropland and orchard reached the maximum was not consistent, and the LAI of orchard occurred earlier than did that of cropland. The LAI of orchard decreased beyond that of cropland at the end of June or the beginning of July. Due to freezing damage that occurred in the spring of 2018, the LAI of the apple orchard was very low in our study.

The total root length density in cropland and orchard within the 0–200 cm soil layers was 16141.4 m m^{-3} and 8344.0 m m^{-3}, respectively (Figure 9). The maize roots displayed a decreasing trend in the 0–200 cm layer. The apple tree roots were longest at 40 cm but then decreased gradually with increasing soil depth. The root length density of maize was greater than that of the apple trees in the soil profile above 120 cm; however, from 120 cm to 200 cm, the root length density of maize was lower than that of the apple trees.

4. DISCUSSION

4.1 Evaporation, Transpiration and Their Proportion of Total *ET*

An understanding of the water balance at a relatively short interval scale and across hydrological years can help to not only compare the water consumption by ET in the active and inactive growth periods but also determine the incremental replenishment of P to the soil reservoir. The water balance is also useful for understanding the impact of plant changes on regional ecohydrology and the potential impact on the soil water environment (Jia et al., 2017; Yimam et al., 2014). The water lost by E_s does not contribute to plant production, and I_c also returns to the atmosphere through evaporative loss. These two components of the total water amount are very important to our research area and to similar dryland ecosystems, where P, the main or sole water resource, has large interannual variability and crops often suffer drought stress (Logsdon et al., 2014).

The peak time of E_s in cropland and orchard was the same in three of the four active growth periods (Table 1), which may indicate that E_s was more closely related to environmental factors than to the influences of different plants (Feng et al., 2019; Sadeghi et al., 2016). The inconsistency in the E_s peak times between cropland and orchard in 2019 may be due to measurement errors during heavy rain events that produced more than 40.0 mm on those days or shading effects by canopy cover. However, according to the Pearson correlation analysis, E_s did not show continuous multiyear correlations with specific meteorological factors (Table 3). This may be the result of the complex, comprehensive effects of environmental factors on E_s (Li, Song, et al., 2020). Nevertheless, it is difficult to completely isolate and determine the impact of a certain environmental factor on E_s. In addition, June was the demarcation month when the E_s of cropland began to be lower than that of orchard. Although the planting date of maize was slightly different each year, maize entered the jointing stage in approximately mid-June. Before this time, the vegetative organs were in the juvenile stage, their resistance to adverse environmental conditions was weak, and their growth was relatively slow (Zhang et al., 2014). While apple trees break dormancy and bloom in early April, new shoot growth, flower bud differentiation and fruit development occur simultaneously around mid-June (Wang & Wang, 2018b). Compared with maize, apple trees are more vigorous and have a greater impact on E_s. After mid-June, the maize leaves fully expanded, and the degree of ground coverage gradually increased (Zhou et al., 2017). While apple trees continued to grow, the LAI of orchard was always less than that of cropland. Based on the change in LAI, it was confirmed that the relative size of E_s was consistent with the relative size of the LAI of both plants in our study. Logsdon et al. (2014) also indicated that the LAI was mainly responsible for the difference in E_s. Yaseef et al. (2009) indicated that the E_s of the Yatir ecosystem decreased from 150.0 to 86.0 mm year^{-1} from an undeveloped canopy cover of 10.0% to full canopy closure. Moreover, the senescence of the leaves did not cause an increase in E_s at the later stage of plant growth. This may be related to the decrease in solar radiation, AT, and VPD and the increase in RH (Ma et al., 2020). In addition, orchards were managed differently from cropland and have wider crop spacing to allow growth and field management. As a result, more soil water can be evaporated away (Feng et al., 2019). Zhou et al. (2017) found that the E_s of maize on the

Loess Plateau was 36.7% of the ET, and Feng et al. (2019) reported that the E_s of maize in Northwest China constituted 39.9–42.8% of the ET. Zhang and Wang (2017) also found that the E_s of an apple orchard was 22.3–56.5%. Our results were generally consistent with previous results. However, Ma et al. (2020) reported that the E_s/ET of maize was 22.0%, which was lower than our results. The lower P and shorter growth time compared with those in our study were the causes of the differences in these results. The mean E_s/ET of orchard measured by Cao et al. (2021) was 54.3% greater than our findings because our LAI was generally higher than the LAI in their research.

Rainwater first arrives at the surfaces of leaves, and part of that water is intercepted and returns back to the atmosphere through evaporation. Therefore, leaf area is a significant factor affecting I_c. The orchard canopy intercepted more rainwater than the cropland canopy before July, while there was more interception in cropland than in orchard after July, which may be related to the LAI of cropland far exceeding the LAI of orchard after July. Additionally, maize and apple trees progress in different developmental stages. The inconsistencies in the growth of different crops at the same time affect P partitioning and ET consumption in the region (Moran et al., 2009). The peak time of the I_c of cropland occurred when P was heavy and concentrated and when the LAI was relatively high (Table 2, Figure 8). In addition, maize leaves have dense pubescence, which can aid in the interception of considerable rainwater, thus influencing water storage (Zhang et al., 2021). Compared with that of cropland, the peak LAI of orchard occurred earlier, and the peak LAI was not consistent with the peak in P events or amount. The leaves of apple trees have wax on their surface, and rainwater that strikes apple leaves may be more prone to sliding onto the soil surface (Anna et al., 2020). Taken together, these factors lead to marked differences in I_c between cropland and orchard. Anna et al. (2020) also pointed out that the type of leaves, variability in leaf phenology, and P conditions to which leaves are exposed (even between the overstory and forest floor at the same location) varied across plant types, resulting in a wide range of water loss I_c. In addition, higher values of I_c/ET occurred where greater P occurred in the maize cropland (Zheng et al., 2018) and apple orchard (Wang & Wang, 2018a). The similar average between the I_c/ET in cropland and orchard indicates that the effects of canopy interception on ET partitioning should not be ignored.

Except in 2018, the consistent increasing and decreasing trends of T in the maize cropland and apple orchard may imply that plants exhibit similar regulatory mechanisms for T under the combined effects of the same environmental factors (Sadeghi et al., 2016). Wang et al. (2020) pointed out that the T of apple trees was potentially more affected by ET than VPD, and the influence of T among meteorological variables was different in each growth stage of poplar (*Populus trichocarpa* × *P. deltoides*) (Meiresonne et al., 1999). Therefore, it is possible that the complex and comprehensive effects of meteorological factors jointly affected T. The peak time of T in cropland and orchard occurred mainly from mid-July to mid-August (Table 1), which was consistent with the physiological cycles of the maize plants and apple trees (Scott et al., 2021; Zhang et al., 2021). Maize was in the tasseling and silking stages at this time, and the leaves were fully expanded. At this stage, plants compete for growing space, and the T level is the highest (Zhou et al., 2017). Apple trees also grew rapidly during this period and consumed significant water. As plant growth and greening lag at the beginning of the rainy season, plant T lags behind E (Scott & Biederman, 2017; Scott et al., 2021). The studies of Feng et al. (2019) and Wang et al. (2020) suggested that the amount of T for croplands during the active growth period was approximately 127.5 mm and 125.0 mm, respectively. Our results, in which the total T in orchard during the active growth period was greater than that in cropland, were consistent with the results of previous studies. However, Kang et al. (2003) and Zhou et al. (2017) pointed out that the T values of the maize croplands and apple orchards were 313.8 ± 45.9 mm and close to 300.0 mm, respectively. A rough estimate by Gong et al. (2007) for an apple orchard was also greater than our findings. Our results were lower than the abovementioned results because both the maize croplands and orchards were irrigated in the previous studies. The mean P during the maize study period was 630.0 mm year^{-1}, and the growing period (early June to early October) of summer maize was also inconsistent with the growing time of our maize. When the P replenishment soil depth exceeds 300 cm in a long-lasting rainstorm, the T calculated from the water balance method may be slightly overestimated. With the comprehensive difference between the amount of I_c and T for cropland and orchard, it may be possible to appropriately reduce orchard planting density to reduce T or control the planting proportions of cropland and orchards.

The multiple peaks in T/ET in cropland indicated that P will stimulate T after heavy P events and reflect the recovered leaf area and plant productivity following short periods of drought (Figure 3) (Scott et al., 2021). Wang et al. (2021) found that the T of apple trees was severely restricted in 2016 and 2017, when the P was limited and unevenly distributed and when the LAI was relatively low. However, 2020 had the smallest T/ET value in our study (Figure 3). Therefore, it is possible that the effect of P on plant T was greater than that of the LAI. Furthermore, modeling studies in dryland regions indicated that T/ET fluctuates across seasons and years due to varying responses of plants operating in response to different phenological signals and plant cover (Paschalis et al.2018; Reynolds et al., 2000; Scott et al., 2021).

4.2 Comparison of SWS

Both cropland and orchard presented essentially consistent changes in SWS in the short intervals during the active growth period (Figure 4). The soil water budget was adjusted by P, which is the only source of water there because of the deep groundwater level (50–80 m) (Jia et al., 2017). The reason that there was more soil water at depths of 0–100 cm in cropland and orchard than below 100 cm is that no surface runoff is generated, and soil water is sufficiently replenished by P (Jia et al., 2017). There was generally more soil water in deeper layers (below 100 cm) in cropland than in orchard. Previous studies have suggested that P and root uptake can affect the soil water status in the 0–200 cm layers (February & Higgins, 2010; Ma et al., 2013). Our research showed that the root systems of maize plants and apple trees were distributed in the range of 0–200 cm. However, the vertical distribution of the root length density of maize plants and apple trees was different. The roots of maize were distributed more in the soil layer above 120 cm, and the roots of apple trees were distributed evenly throughout the soil profile (Figure 9). Moreover, the apple trees were still in their prime stage, and more water was needed for these trees than for maize. Apple trees are perennial crops that use water throughout the year. As demonstrated by Jin et al. (2011), water use by black locust (*Robinia pseudoacacia* L.) tree initially increases quickly but then gradually decreases with age. Ma et al. (2018) found that the root length density was maximum in the shallow soil layer (0–30 cm) in the maize field, and it was suggested that the root length density in the 0–100 cm layer decreased with increasing SWS. Li et al. (2018) indicated that the roots of 22-year-old apple trees could be as deep as 23.2 m, so the apple trees consumed more deep-layer (below 100 cm) water than the maize did. Wang et al. (2021) showed that trees have a relatively deep root system and that the soil water in the deeper layers was used by only the trees in the studied agroforestry system.

4.3 Comparison of Water Consumption and Analysis of Related Factors

Determining water consumption in hydrological years is essential for understanding water use in dryland ecosystems and for promoting sustainable environmental development. The mean ΔSWS in cropland during the active growth period was less than that in orchard, and

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the mean ET was greater than that in orchard (Figure 5). The I_c of orchard was less than that of cropland, and more water from TF and SF was present in the soil, replenishing the soil reservoir. All the total ΔSWS values of cropland and orchard in each active growth period were positive. The soil water consumption of orchard and its influence on the soil water at 0–300 cm were not found to have a negative effect on soil water storage until the present study. The inconsistency between our results and those of Jia et al. (2017) and Zhao et al. (2007) may be due to the different sampling depths of SWS, which in their studies were 100–500 cm and 0–1000 cm, respectively. Precipitation was not sufficient to replenish the deep soil water in the above studies. Compared with the findings of those studies, our measurement depth of SWS could be considered only as a shallow layer, which was sufficiently replenished by P. The ET of both cropland and orchard was less than the cumulative P in the corresponding time interval during the active growth period, which demonstrated that the ET demand for cropland and orchard could be met by P. The positive correlations of PET and ET in maize cropland and orchard also indicated that the P supplement was sufficient during the active growth period (Liu & Yang, 2010). In addition to meeting the growth requirements of plants, excess P infiltrates the soil, thereby replenishing the soil reservoirs of croplands and orchards. The ΔSWS of cropland in 2017 was greater than that of orchard, and the ET was less than that of orchard, while the relative sizes of the ΔSWS and ET values in 2018–2020 were the opposite of those in 2017. One reason is that the maximum LAI of maize occurred earlier in 2017 than in other years and didn't coincide with the time at which the P was most concentrated. When the P events were concentrated, the soil water was fully replenished.

During the inactive growth period in 2017–2018, the ΔSWS of orchard was positive and was greater than that of cropland (Figure 6). However, the SWS of cropland was greater than that of orchard at the beginning of the inactive growth period, and no plants covered cropland during the inactive growth period. When there are no plants, significant soil water can be lost through E_s (Logsdon et al., 2014). After being supplied by P, apple trees can capture a certain amount of water and store water in their roots during this period. During the inactive growth periods in 2018–2019 and 2019–2020, the ΔSWS of orchard was negative, and the absolute value of ΔSWS was greater than that of cropland. This difference occurred because the apple trees were in their fruit-accumulation stage and still consumed soil water in October. Afterward, the apple trees bloomed and started to germinate in early April, when they had already begun to consume soil water. In general, the growth cycle of apple trees that are actively consuming water is longer than the growth cycle of maize. When maize was harvested, the ET in the inactive growth period was based on E_s. However, the ET was mainly composed of T and E in orchard during the inactive growth period (Qiao et al., 2015).

The difference in total ET among the three hydrological years mainly resulted from the different meteorological conditions (Tanaka et al., 2008; Yimam et al., 2014). The ET of orchard was greater than that of cropland only in the hydrological year of 2019–2020 (Table

2). This may be closely related to the fact that the P in the hydrological year of 2019–2020 far exceeded that in the other two hydrological years. In water-limited systems, ET partitioning is expected to be controlled mainly by surface properties such as soil water content and vegetation cover/function rather than atmospheric demand (Scott et al., 2021). The proportion of ET in the inactive growth period to the total ET in a given year should not be ignored. Greater attention should be given to water loss at this stage in dryland management, especially in rainfed areas. The ET in the inactive growth period of orchard was greater than that of cropland, which was related to the artificially determined period of inactive growth. In addition, Han et al. (2015) showed that the mean annual PET was 949.3 mm in the Changwu tableland from 1957 to 2012, which was slightly higher than our result (924.1 mm) (Figure 7). The inconsistent between results partly caused by the different range of hydrological year for calculating PET. The difference between PET and ET for maize cropland and orchard at hydrological year scale had obvious characteristic, because there was much P during 2019-2020 and P stimulated the increase of ET (Liu & Yang, 2010).

The total ΔSWS across the three years for cropland was lower than that of orchard, which was principally because of freezing damage that occurred in the spring of 2018. Freezing damage greatly affected the growth of the apple trees, resulting in a relatively small change in soil water in the hydrological year of 2018–2019 and affecting the total ΔSWS. These findings indicated that the growth of plants had an obvious influence on the environment, especially on the soil water (Cao et al., 2021; Li, Tang, et al., 2020). The difference in total ΔSWS for orchard and cropland was small for the 0–300 cm soil layer, and no significant difference existed in ET according to our results. However, increased attention should be given to the management of apple orchards in similar dryland ecosystems because apple trees are deep-rooted plants.

5. CONCLUSIONS

Based on continuous field observations, we studied ET subcomponents and water consumption in a maize cropland and an apple orchard. We classified E_s and I_c as E components of ET and accounted for active and inactive periods of crop growth. The effective water use in the active growth period and water loss in the inactive growth period of plants could be carefully determined through division into short intervals. June was the demarcation month for the difference in E_s between cropland and orchard. Through the change in LAI, it was confirmed that the relative size of E_s was consistent with the relative size of the LAI of the two plants. The value of I_c was significantly different between cropland and orchard, but the mean I_c/ET for cropland and orchard were similar in the active growth period. A significant difference in T existed between cropland and orchard, and the multiple peaks in T/ET in cropland indicate that T was stimulated by heavy P. The significant differences in T and I_c between cropland and orchard provide important implications for optimizing field water management in dryland ecosystems. The SWS values of cropland and orchard in the 0–300 cm layer were influenced by P. All the total ΔSWS values of the 0–300 cm layer in orchard in each active growth period for four years were positive because the effect on the soil water at 0–300 cm had not yet reached the negative level. The water demand of ET in cropland and orchard could be met by P during the active growth period. ET was dominated by E_s in cropland during inactive growth periods, but ET was mainly dominated by T and E_s in orchard. To achieve the sustainability of soil and environmental management, attention should be given to soil water storage, and existing management strategies of orchards should be developed for the whole growth period.

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AUTHOR CONTRIBUTIONS

Rui Zhang: Conceptualization; Data curation; Formal analysis; Writing – original draft. Jinghan Ma: Investigation. Katsutoshi Seki: Writing - review& editing. Di Wang: Writing - review& editing. Li Wang: Supervision, Funding acquisition, Writing - review& editing.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Figure captions

FIGURE 1 Location of the study area and sampling sites on the Loess Plateau of southern Shaanxi, China.

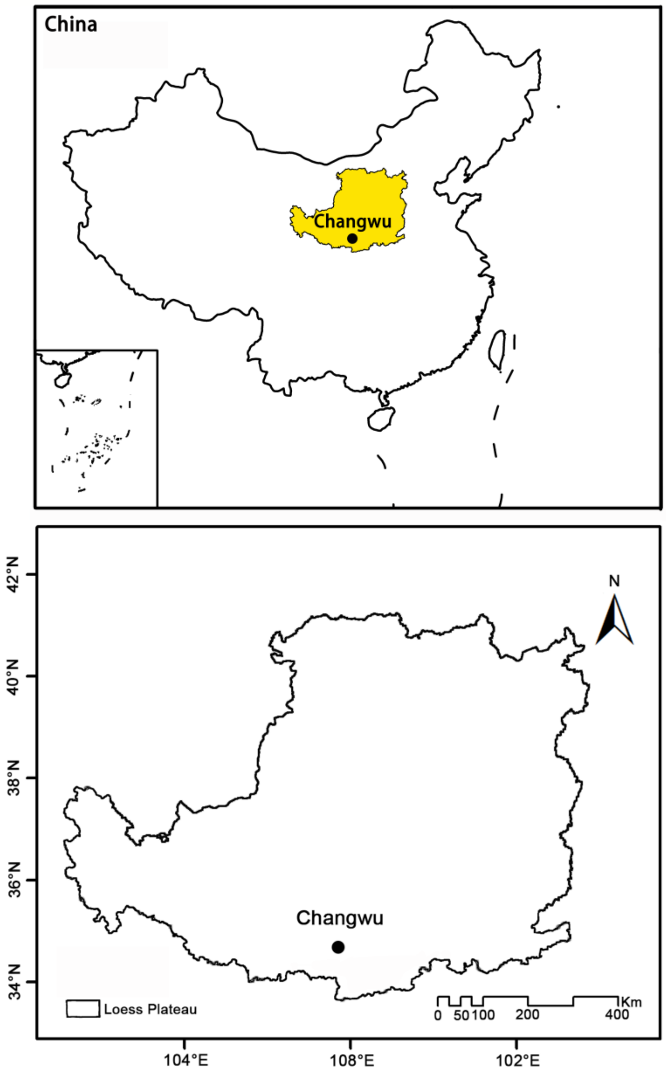


FIGURE 2 Seasonal variation in meteorological conditions: (a) daily and monthly precipitation (P), (b) daily air temperature (AT), (c) daily wind speed (Ws) and daily relative humidity (RH), and (d) daily soil temperature (ST) in the active growth period (May to September) in 2017–2020.

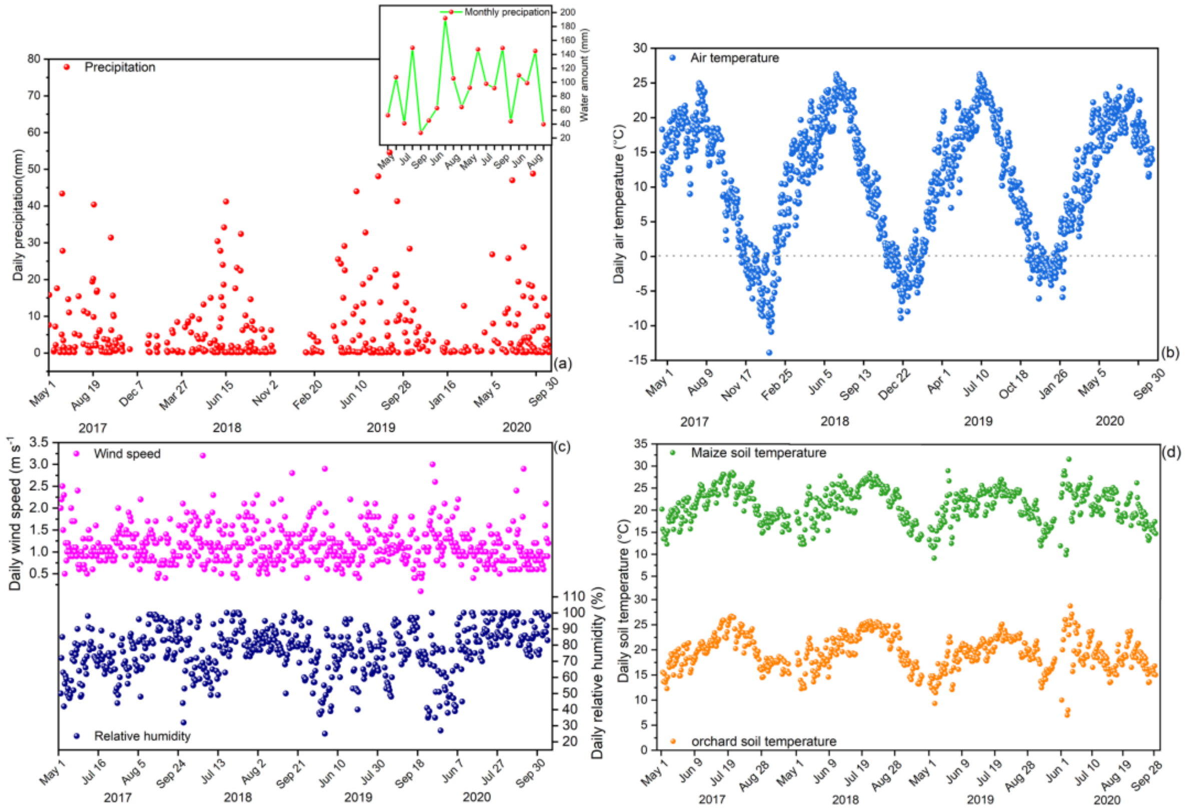


FIGURE 3 Variation in the proportions of transpiration and evaporation out of evapotranspiration (T/ET, E/ET) in four active growth periods. (a): cropland; (b): apple orchard.

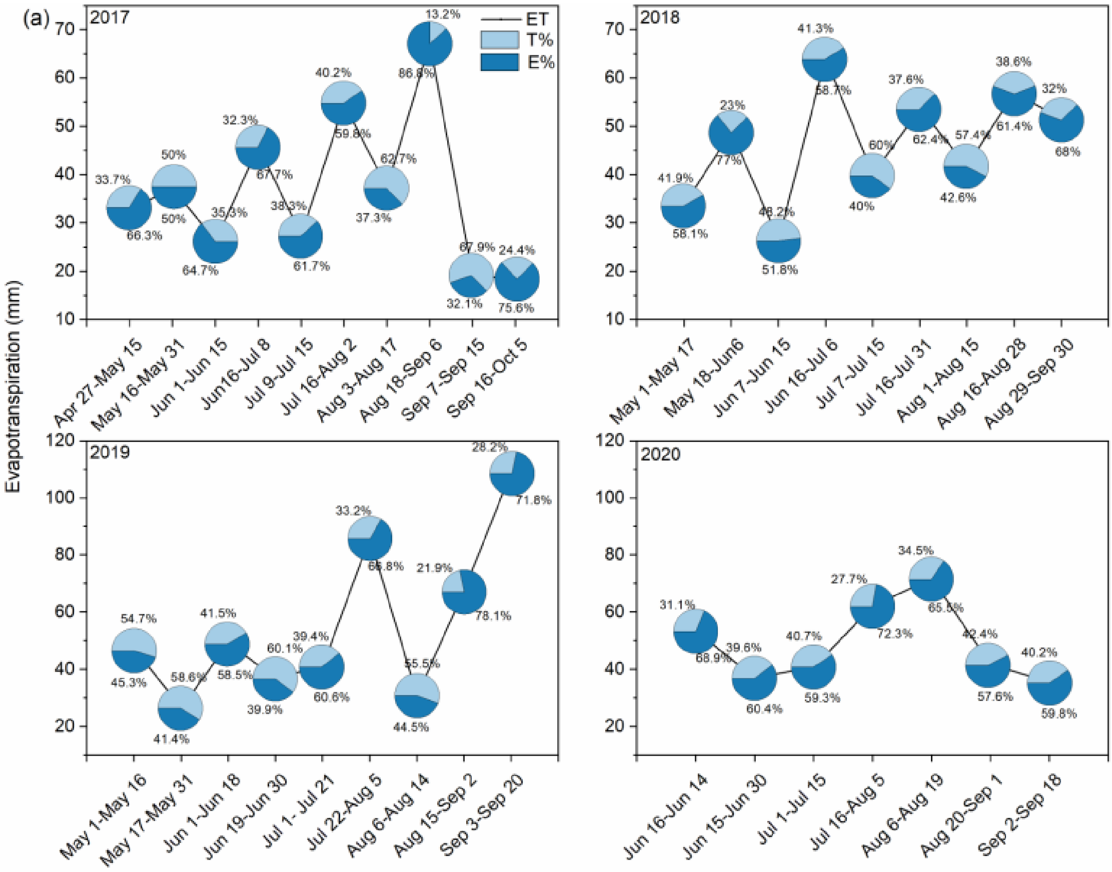


FIGURE 4 Vertical distribution and temporal dynamics of soil water storage (SWS) from 0–300 cm under (a) cropland and (b) apple orchard.

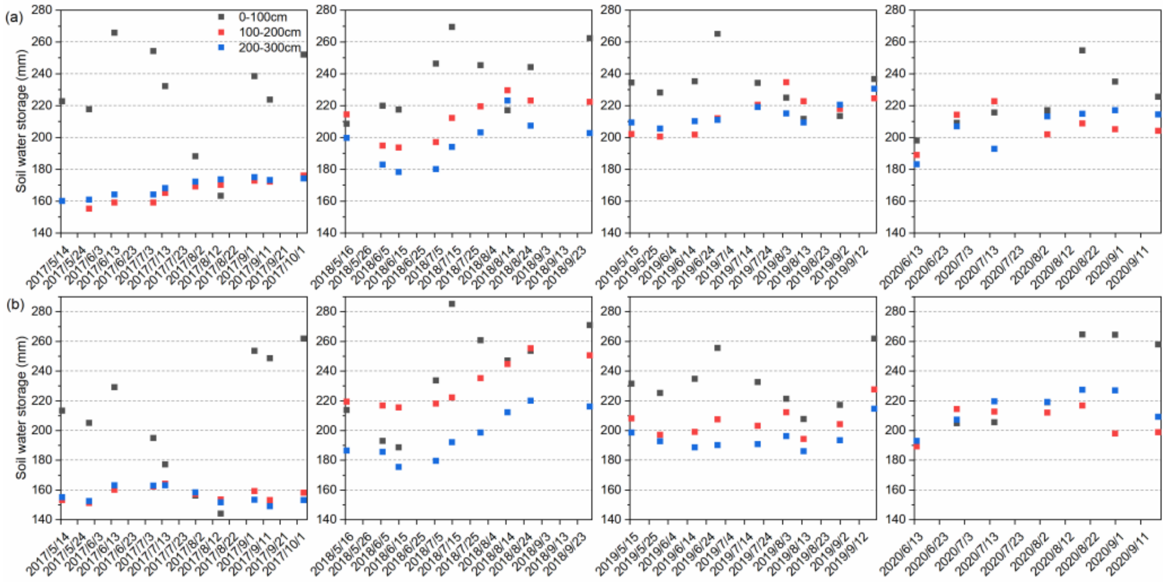


FIGURE 5 Variations in evapotranspiration (ET) and changes in soil water storage (ΔSWS) in the maize cropland and apple orchard throughout four active growth periods. 2017, 2018, 2019 and 2020 represent active growth periods.

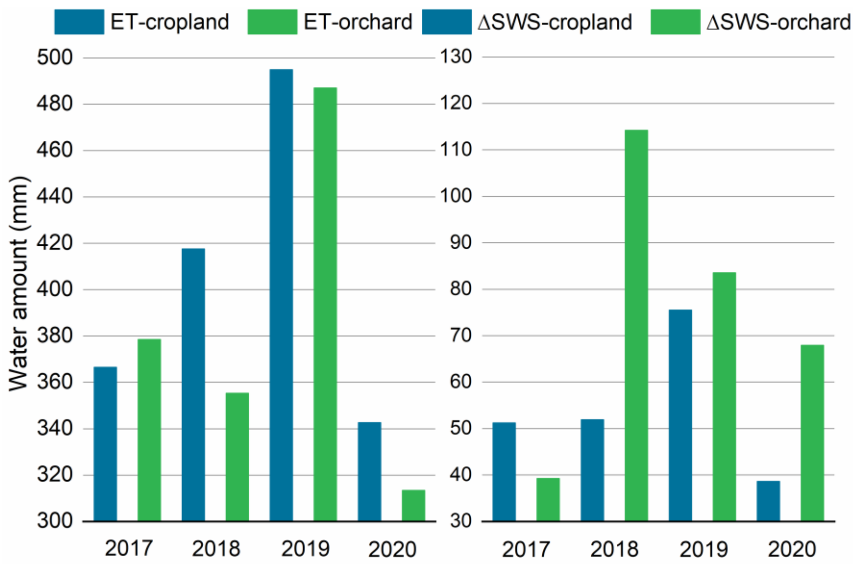


FIGURE 6 Variations in evapotranspiration (ET) and changes in soil water storage (ΔSWS) in the maize cropland and apple orchard during three inactive growth periods. (a) cropland and (b) orchard. 2017–2018, 2018–2019 and 2019–2020 represent inactive growth periods.

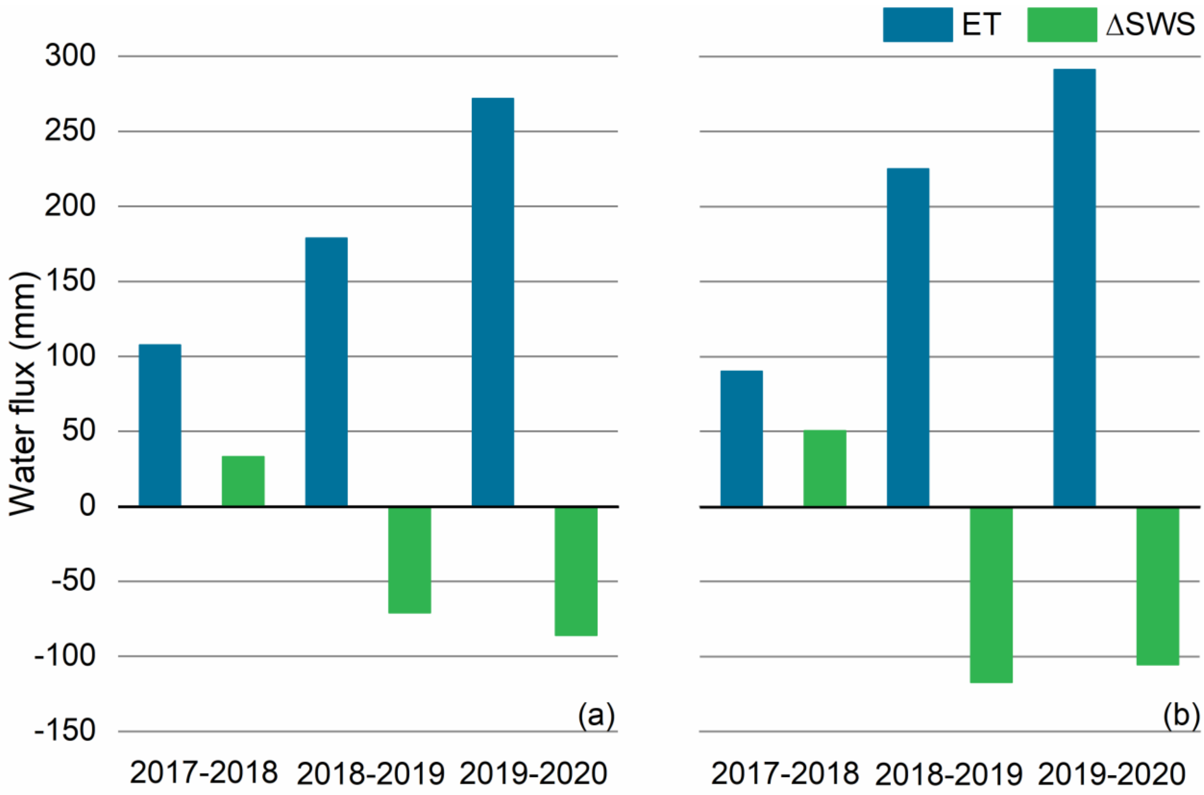


FIGURE 7 Relationships and comparisons between potential evapotranspiration (PET) and evapotranspiration (ET) for maize cropland and apple orchard during experimental periods. (a): active growth period, linear regressions are shown as solid dashes. (b): inactive growth period and hydrological year. The blue and red bars are the difference between PET and ET.

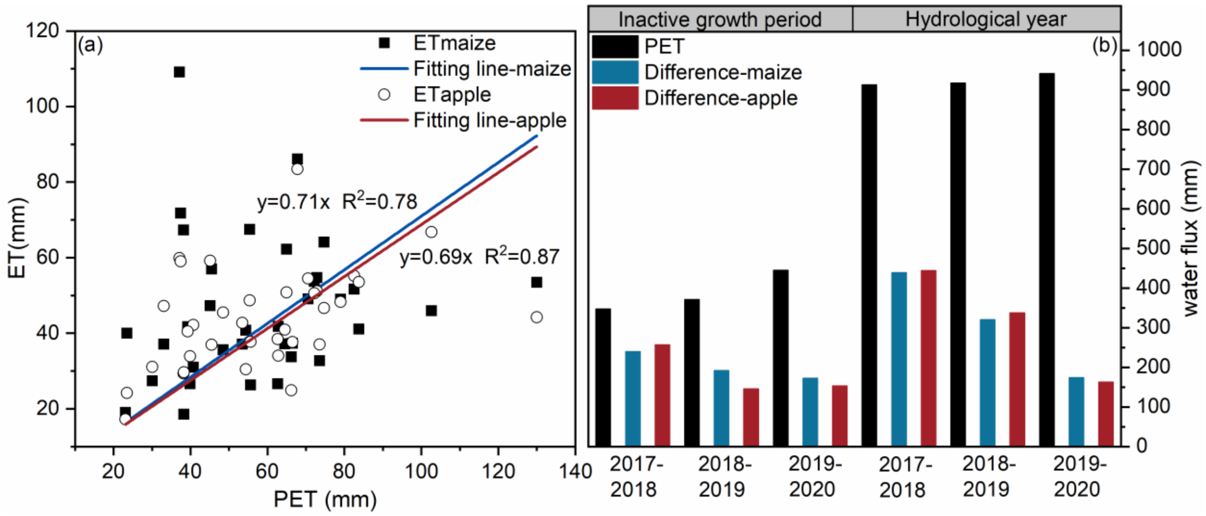


FIGURE 8 Variations in leaf area index (LAI) from May 2017 to September 2020.

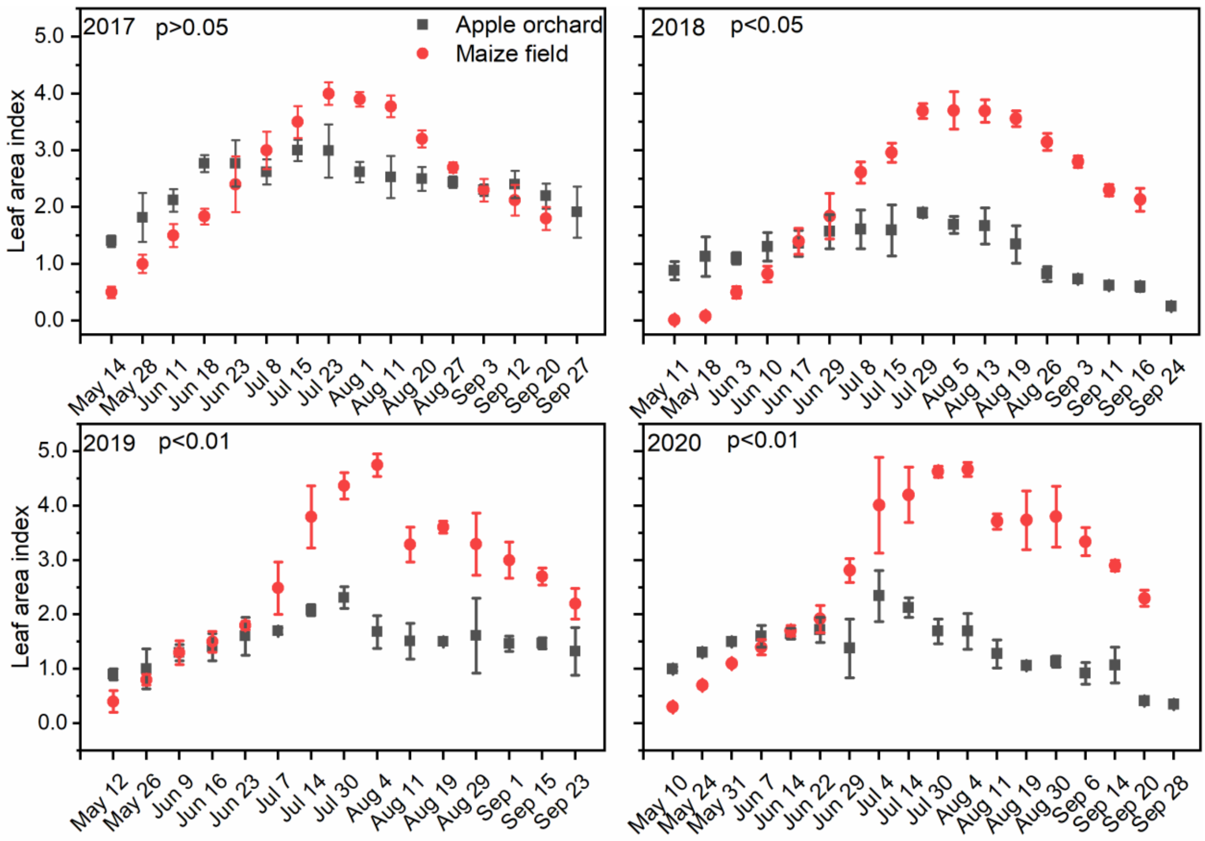
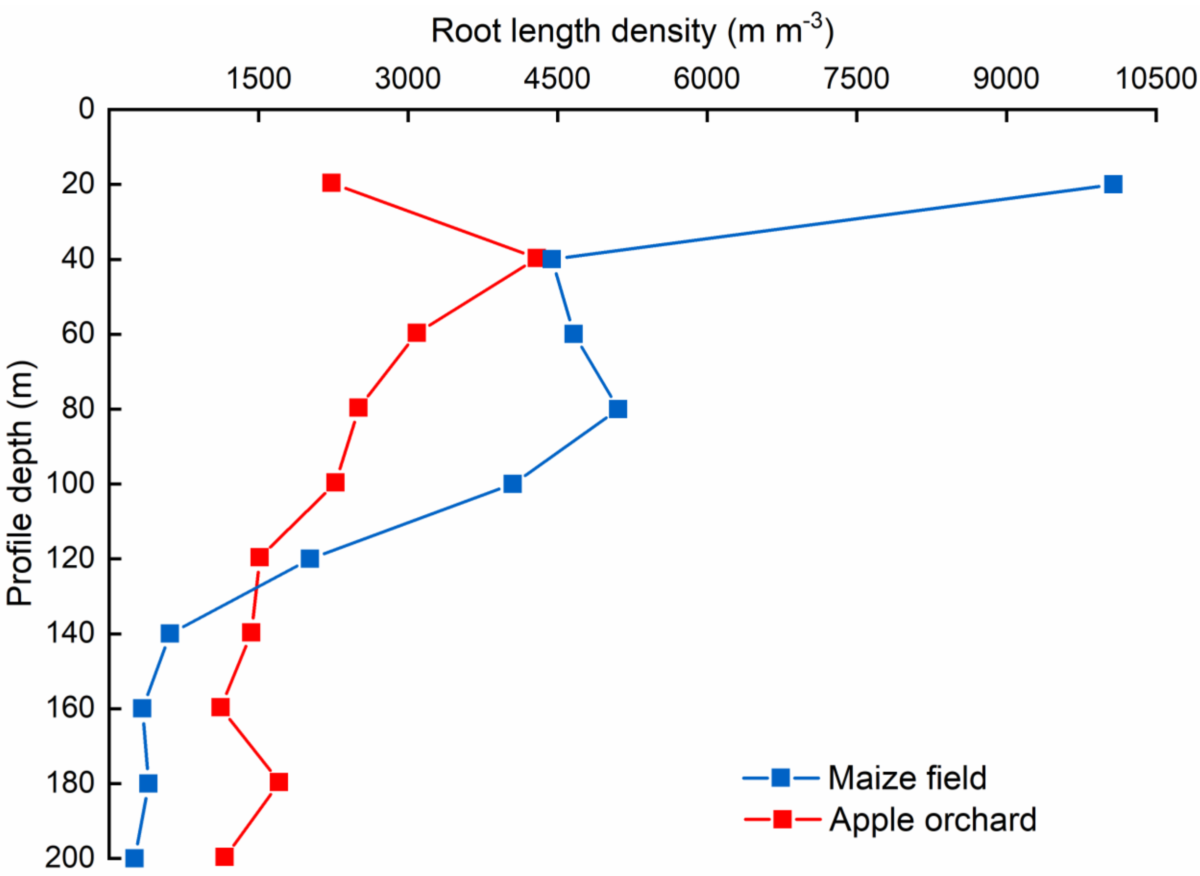


FIGURE 9 Vertical distribution of roots in the maize cropland and apple orchard.



Tables

TABLE 1 Comparison of soil water evaporation (E_s), transpiration (T) and canopy interception (I_c) in the maize cropland and apple orchard during active growth periods in 2017–2020.

Year	Date	E_s (mm)		I_c (mm)		T (mm)	
		Cropland	Orchard	Cropland	Orchard	Cropland	Orchard
2017	4/27–5/15	20.5	19.3	1.2	5.2***	11.0	12.5
	5/16–5/31	15.5	12.8***	3.1	8.0***	18.6	20.1
	6/1–6/15	6.7	9.2***	10.3	15.6***	9.3	13.0***
	6/16–7/8	17.8	20.3**	13.3	21.8***	14.8	24.6***
	7/9–7/15	3.7	5.8***	13.2	8.1***	10.5	17.1***
	7/16–8/2	23.8	26.0	8.9	7.3*	22.0	17.8***
	8/3–8/17	9.2	13.3***	4.7	2.5***	23.4	21.9
	8/18–9/6	10.3	13.7***	48.1	9.8***	8.9	5.9***
	9/7–9/15	5.8	7.3***	0.3	0.8***	12.9	9.1***
	9/16–10/5	14.0	10.7***	0.0	5.4***	4.5	13.5***
	Total	127.3	144.3**	103.1	84.5***	136.0	155.6**
2018	5/1–5/17	18.6	15.3***	1.0	4.0***	14.1	5.6***
	5/18–6/6	37.7	30.2***	0.0	4.4***	11.3	13.7*
	6/7–6/15	11.7	17.4***	2.1	3.6***	12.8	12.9
	6/16–7/6	18.2	14.0***	19.4	15.1***	26.5	17.5***
	7/7–7/15	0.0	0.0	16.0	8.7***	24.0	15.5***
	7/16–7/31	31.0	19.5***	2.5	3.9***	20.2	27.1***
	8/1–8/15	4.3	4.5	13.5	5.9***	24.0	23.6
	8/16–8/28	8.3	11.2***	26.7	6.5***	22.0	19.2*
	8/29–9/30	27.2	30.1**	7.9	12.2***	16.5	12.9***
	Total	157.0	142.2**	89.1	64.3***	171.4	148.0**

2019	5/1–5/16	20.9	17.5**	0.5	10.8**	25.9	30.8*
	5/17–5/31	11.0	9.6*	0.0	5.4**	15.6	23.4**
	6/1–6/18	28.7	22.7**	0.0	11.1**	20.4	20.7
	6/19–6/30	11.5	11.5	3.3	8.5**	22.3	27.2*
	7/1–7/21	11.9	20.3**	13	9.7**	16.2	23.5**
	7/22–8/5	14.0	19.6**	43.5	31.8**	28.6	32.0
	8/6–8/14	13.6	18.8**	0.2	0.2	17.2	23.2**
	8/15–9/2	16.0	23.0**	36.7	10.0**	14.8	15.7
	9/3–9/20	15.2	17.7*	63.1	8.9**	30.8	33.3
	Total	142.8	160.7*	160.3	96.4**	191.8	229.8*
2020	5/16–6/14	36.8	32.2*	0.0	1.0**	16.6	11.0**
	6/15–6/30	21.8	18.6**	0.6	3.9**	14.7	20.3**
	7/1–7/15	13.5	14.2	10.7	4.7**	16.6	11.6**
	7/16–8/5	17.7	17.5	27.3	14.2**	17.2	19.1
	8/6–8/19	4.4	6.8**	42.6	13.9**	24.8	38.4**
	8/20–9/1	8.7	20.9**	15.3	6.4**	17.7	13.2**
	9/2–9/18	14.6	20.4**	6.7	8.9*	14.3	16.2
	Total	117.5	130.6*	103.2	53.0**	121.9	129.8

Note: ANOVA * and **significance at $p<0.05$ and <0.01 within years, respectively.

TABLE 2 The characteristics of water consumption during hydrological year

		Cropland	Orchard
ET-inactive/ET-year (%)	2017-2018	22.7	19.3
	2018-2019	30.0	38.8
	2019-2020	35.5	37.4
ET (mm)	2017-2018	474.1	468.7
	2018-2019	596.5	579.9
	2019-2020	766.9	778.3
ΔSWS (mm)	2017-2018	84.3	89.7
	2018-2019	-19.2	-3.1
	2019-2020	-10.7	-22.1

Note: ET-inactive: the ET of inactive growth period, ET-year: the ET of hydrological year, ΔSWS: changes in soil water storage.

TABLE 3 Pearson correlations between soil water evaporation (E_s), transpiration (T), evaporation (E) and meteorological variables during the active growth period.

			AT (°C)	RH (%)	Ws (m s^{-1})	P (mm)	ST (°C)	VPD (kPa)
Cropland	2017	E_s	-0.034	0.462	-0.237	0.788*	-0.090	0.170
		T	0.682*	-0.061	-0.132	-0.513	0.420	0.613
		E	-0.010	0.223**	0.098	0.418**	-0.029	-0.320
	2018	E_s	-0.050	0.031	0.164	0.265	-0.035	0.433
		T	0.719*	0.856**	-0.649	0.820**	0.638	-0.594
		E	0.079	0.059	0.123	0.533**	0.085	-0.042
	2019	E_s	0.069	0.462	-0.224	0.810**	-0.081	-0.061
		T	-0.236	0.285	-0.135	0.797*	-0.354	-0.230
		E	0.028	0.137	0.008	0.657**	-0.066	-0.208
	2020	E_s	0.516	0.900*	-0.138	0.593	0.196	0.618
		T	0.299	0.828*	0.061	0.585	-0.014	-0.154
		E	0.060	0.229**	0.027	0.528**	-0.032	-0.066
Orchard	2017	E_s	0.218	0.013	-0.161	0.337	0.150	0.252
		T	0.343	-0.529	0.073	-0.670*	0.529	0.714*
		E	0.052	0.054	0.112	0.278**	0.078	0.193
	2018	E_s	-0.556	-0.328	0.362	-0.053	-0.527	0.396
		T	0.917**	0.494	-0.136	0.265	0.937**	-0.031
		E	0.041	-0.153	0.032	0.107	0.071	0.128
	2019	E_s	0.510	0.149	0.350	0.475	0.470	-0.138

	T	0.056	0.149	0.454	0.649*	0.010	-0.175
	E	0.116	-0.005	-0.035	0.430**	0.044	0.225
	E_s	0.515	-0.209	-0.035	0.038	0.487	0.526
2020	T	0.063	0.618	-0.102	0.768*	-0.514	-0.226
	E	0.193*	0.180*	0.028	0.150	0.069	0.118

Note: * and **significance at p<0.05 and <0.01 within years, respectively. AT: air temperature; RH: relative humidity; Ws: wind speed; P: precipitation; ST: soil temperature; VPD: vapor pressure deficit.

TABLE 4 Pearson correlations between evapotranspiration (ET) and precipitation (P) in hydrological years.

Hydrological year			P
2017–2018	ET	Cropland	0.351
		Orchard	0.019
2018–2019	ET	Cropland	0.834**
		Orchard	0.637**
2019–2020	ET	Cropland	0.878**
		Orchard	0.757**

Note: * and **significance at p<0.05 and <0.01, respectively